

WVT-TR-77002

AD

DEVELOPMENT OF IMPROVED RIFLING  
PROCEDURES AND EQUIPMENT

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TECHNICAL REPORT

AMCMS No. 3297.06.7402

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  This report describes a process of rifling two 105mm M2A2 gun barrels simultaneously in a horizontal side by side position.  The purpose of the project was to reduce significantly rifling machining time of 105mm gun barrels by a process that would be readily adaptable to production line quantities.		

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## STATEMENT OF THE PROBLEM

The machining operation known as rifling, or broaching of gun tubes, has always been a time consuming operation. For example, because of the necessity of passing 49 broaches through the bore of the 175mm M113 gun tube to attain full groove depth, the rifling operation requires as much as 11.9 hours. A procedure that would considerably reduce rifling machining time and maintain required accuracy was the desired goal of this project.

Areas for improvement in attempting to reduce rifling time are rather limited. The speed of the rifling stroke is largely dependent upon the cutting tool material. Another area given consideration was machine loading and unloading, but the time gained in this area of effort would not represent the substantial savings that were being sought. Some increase in the speed of the rifling bar return stroke would be helpful in reducing the non-productive portion of the operating cycle but this again was not thought to be significant.

The possibility of rifling by using more than one cutter or broach at the same time was also given consideration. The power required to pass a rifling cutter (broach) through the bore of a gun tube is relatively low, and the structure of the machine is capable of several times the loading applied. In actuality, rifling machines are considerably overpowered for the rifling operation and, therefore, in a sense are not being utilized to their full potential.

## BACKGROUND AND INTRODUCTION

In the field of cannon making, one of the major products is the gun tube which launches the projectile toward its intended target. In rifled tubes, the rotation of the projectile on its axis provides stability in flight. A spiral pattern of grooves (Figure 1) is machined in the bore diameter to initiate the projectile spin. These grooves and the machining operation to form them are known as rifling. Since its inception at Watervliet Arsenal, the concept of rifling gun tubes has changed very little. The method is one that removes a small amount of stock from the diameter of the groove area on each pass, progressively increasing the size of the cutter (Figure 2) until the finish depth of the rifling grooves is reached. This process is necessary to achieve the dimensional accuracy and finish requirements that assure an acceptable product.

There have been previous evaluations and attempts to increase the efficiency of the rifling operation. It was thought that if several cutting broaches were mounted on a single head this would reduce machining time. In one attempt, ten (10) cutter broaches were mounted on one head. The results were most unsatisfactory. The cut being unusually long presented serious chip accumulation problems. Other attempts were made until the number of cutters were reduced to two. This attempt also failed due to a differential in torsional deflection from cutter to cutter. The second cutter would assume different angular positions with succeeding passes. Thus, multiple cutters or



broaches mounted on the same bar do not perform satisfactorily. Additional efforts were made to increase machining rates by using carbide cutters or various grades and qualities of high speed steel. The incidence of a catastrophic failure is disturbingly high with carbide, and experimentation with various high speed steels proved nonproductive. The attempts, although negative, narrowed the direction in which further attempts would be directed.

#### APPROACH TO THE PROBLEM

It was decided that a new approach to the problem was necessary and that it would be in the area of rifling more than one gun tube at the same time. As previously noted, the basic rifling machine is considerably overpowered and therefore not utilized as economically as it could be. When examination of the feasibility of rifling more than one gun tube at a time showed promise, efforts were concentrated in this direction.

Evaluation studies were conducted for the purpose of determining the advantages that could be realized by the successful adaptation of a process of duplex rifling. The successful application of duplex rifling indicated that the following advantages could be realized:

- a. Reduced machining time.
- b. Reduced capital investment costs.
- c. Reduced floor space requirements.
- d. Reduced set-up time.
- e. Improvement of the state of the art.

## DISCUSSION OF RESULTS

With the decision to develop a process for rifling two gun tubes simultaneously (and since it was an entirely new concept) it was decided that initial tests would be concentrated on a short gun tube. The 105mm M2A2 Howitzer was selected. A design was conceived, refined, and finalized for the development of a system for duplex rifling that would adapt to a Niles Rifler WV6695\*. A request was issued to purchase the necessary castings to conform to Federal Specification QQ-I-652C dated 20 May 1970, Class 30B to 35B. A contract, #75M0235, was placed with Ross Valve Mfg., Troy, N.Y. for manufacture of the castings, and delivery was completed in June 1975. Appendix A is a compilation of drawings of the castings procured, while Appendix B is a compilation of finished parts drawings. All other hardware items such as broaches, broach heads, rifling bars, etc., were manufactured by the Arsenal Operations Directorate.

Figures 3-11 show the various components of the assembled system. Figure 3 (Drawing WTV-D24987) shows the layout of the machine, locating the various components. The essential items (with referenced figures) are shown below:

- Item # 1 - Crosshead Rifling Bar Drive - Figures 4,9
- 2 - Coolant Lines - Figure 4
- 3 - Rotary Couplings - Figure 4

\*This machine was the only rifler available when the project was being conducted.

Item #	4 - Coupling Plate	- Figure 4
	5 - Coolant Trough	- Figure 5
	6 - Coolant Exhaust Line	- Figure 5
	7 - Rifling Heads	- Figures 6,7
	8 - Rifling Cutters	- Figures 6,7
	9 - Tube Clamping Fixture	- Figure 6
	10 - Tube Positioning Fixture	- Figure 6
	11 - Tube Centering Fixture	- Figures 7,8
	12 - Broach Head Support Fixture	- Figures 7,8
	13 - Rifling Bar Drive	- Figure 8
	14 - Key Guide Blocks	- Figure 8
	15 - Weights	- Figure 9
	16 - Weight Guides	- Figure 9
	17 - Pulley System	- Figure 9
	18 - Metal Particle Separator	- Figure 10
	19 - Rifling Bars	- Figure 11
	20 - 105mm M2A2 Tubes	- Figure 11

Manufacture of the complete system was concluded in January 1976 and installation completed by February 1976. Initial testing of the duplex rifling system occurred in March 1976 with the first set of finish rifled 105mm M2A2 tubes (Figure 11) being completed March 1976. The tubes were examined by Quality Control personnel and both dimensional and surface finish requirements were acceptable. Further rifling tests were made to demonstrate to Arsenal Operations Directorate personnel the feasibility of duplex rifling. Some changes

and modifications have been incorporated into the original design to refine and improve the system. All drawings have been updated to reflect these refinements. There were no problem areas of any significance that were confronted through the development, manufacture, installation and testing of the system.

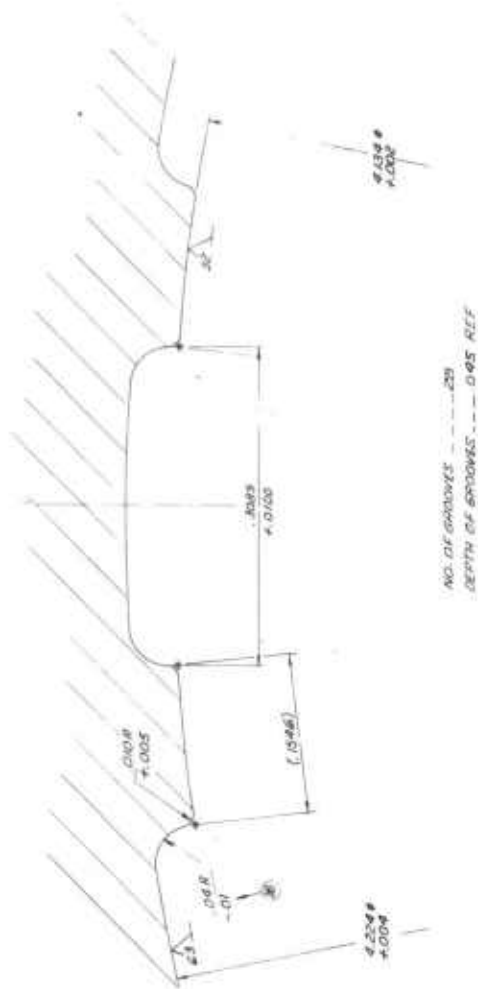
Savings of approximately 35 to 40 percent can be anticipated on adaptation of duplex rifling of small caliber gun tubes. This is based on comparison of the time required to rifle a 105mm M2A2 gun tube by existing single bar rifling methods, to the duplex system as developed by this MM&T project (Table 1 - Comparative Costs for Rifling Tubes).

#### CONCLUSIONS AND RECOMMENDATIONS

The successful application of duplex rifling initially performed on two 105mm M2A2 gun tubes and subsequent further rifling tests on the same caliber gun tube have proved that this process is feasible and economically sound. For this reason, it is recommended that a strong effort be made to apply this duplex process of rifling gun tubes to the 105mm M68. This being a high volume production item, the savings realized would be considerable. The design of the system for rifling the 105mm M2A2 is readily adaptable to 105mm M68 conversion and will require a minimum of effort.

The duplex system for rifling gun barrels is a highly productive production innovation for increasing component output, resulting in substantial cost savings. Reduced floor space and manpower requirements are additional tangible savings. The incorporation of this new

rifling process enhances the production capabilities of Watervliet Arsenal by introducing a superior system for rifling gun tubes.



NOTE:  
THE WIDTHS SHOWN FOR LANDS AND GROOVES ARE NORMAL TO THE AXIS  
OF THE GUN AND ARE ON THE ARC. ECCENTRICITY OF .004 IS ALLOWED  
BETWEEN BORE AND OUTSIDE DIAMETER OF RIFLING.

Figure 1. Tube - rifling detail (F8765961, sheet 4 of 4).

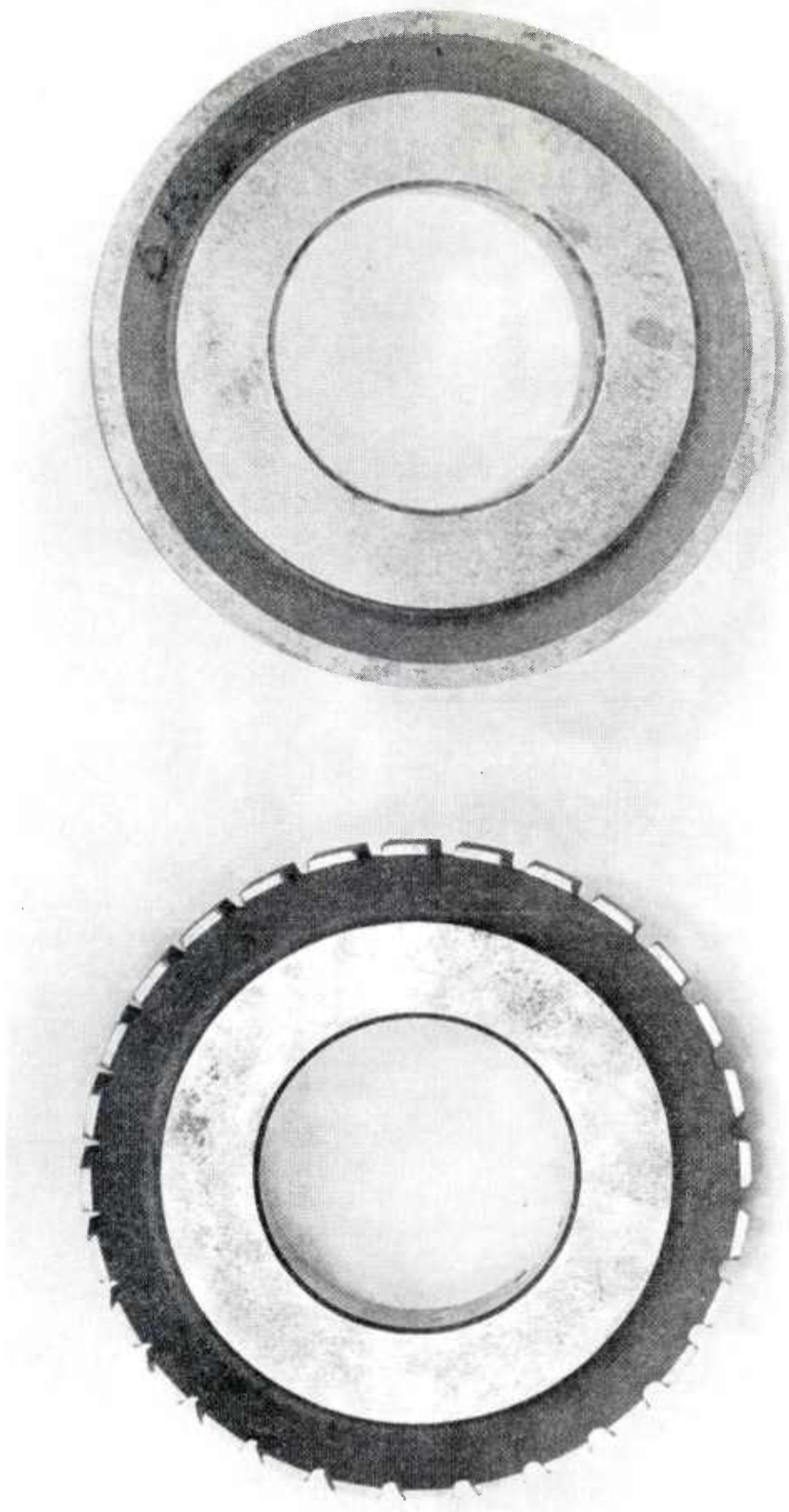


Figure 2. View of rifling broaches used to rifle gun tubes. Broach on right is a cutter blank. The left broach is semi-finished (310-5-73).

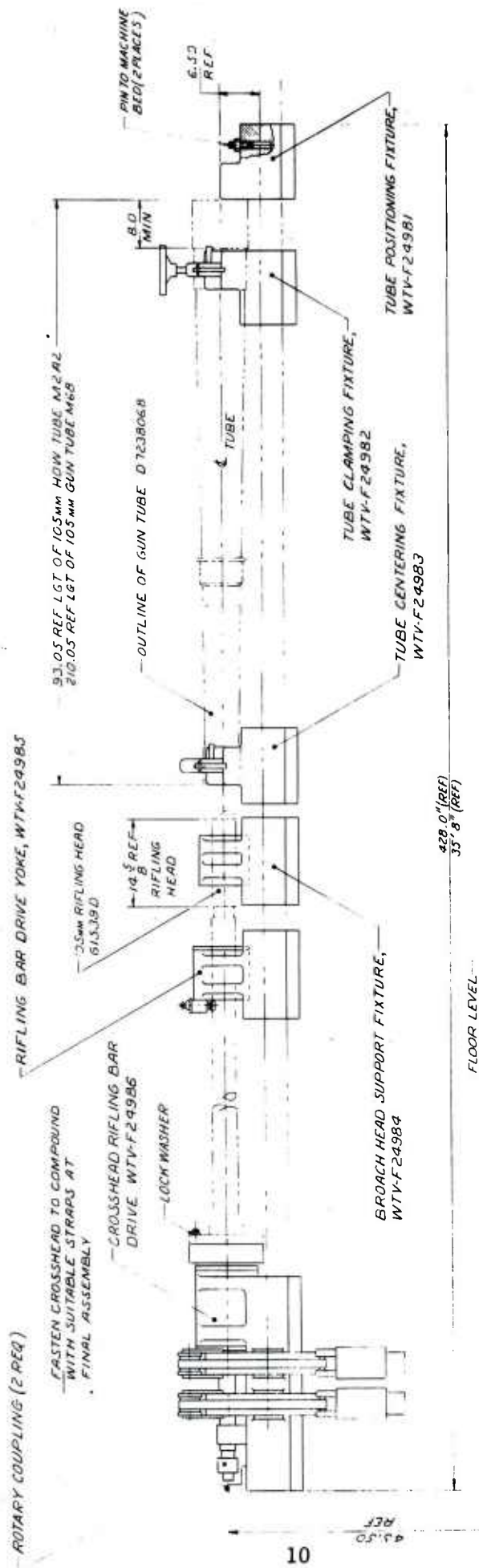


Figure 3. Setup sheet for rifling two tubes (WTV-D24987).



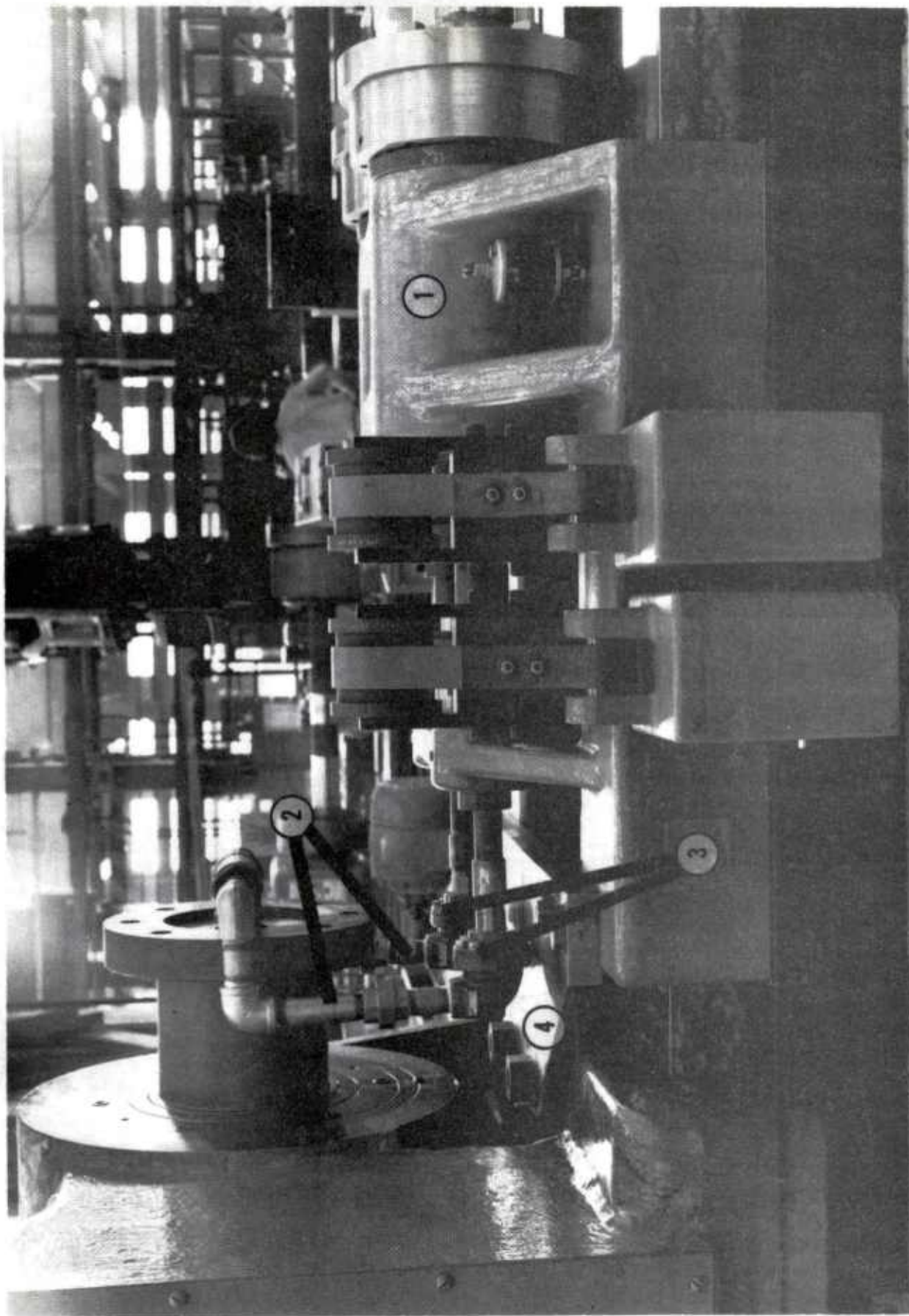


Figure 4. View of Crosshead Rifling Bar Drive (WTV-F24986) showing coolant lines, rotary couplings, and coupling plate (160-1-76).

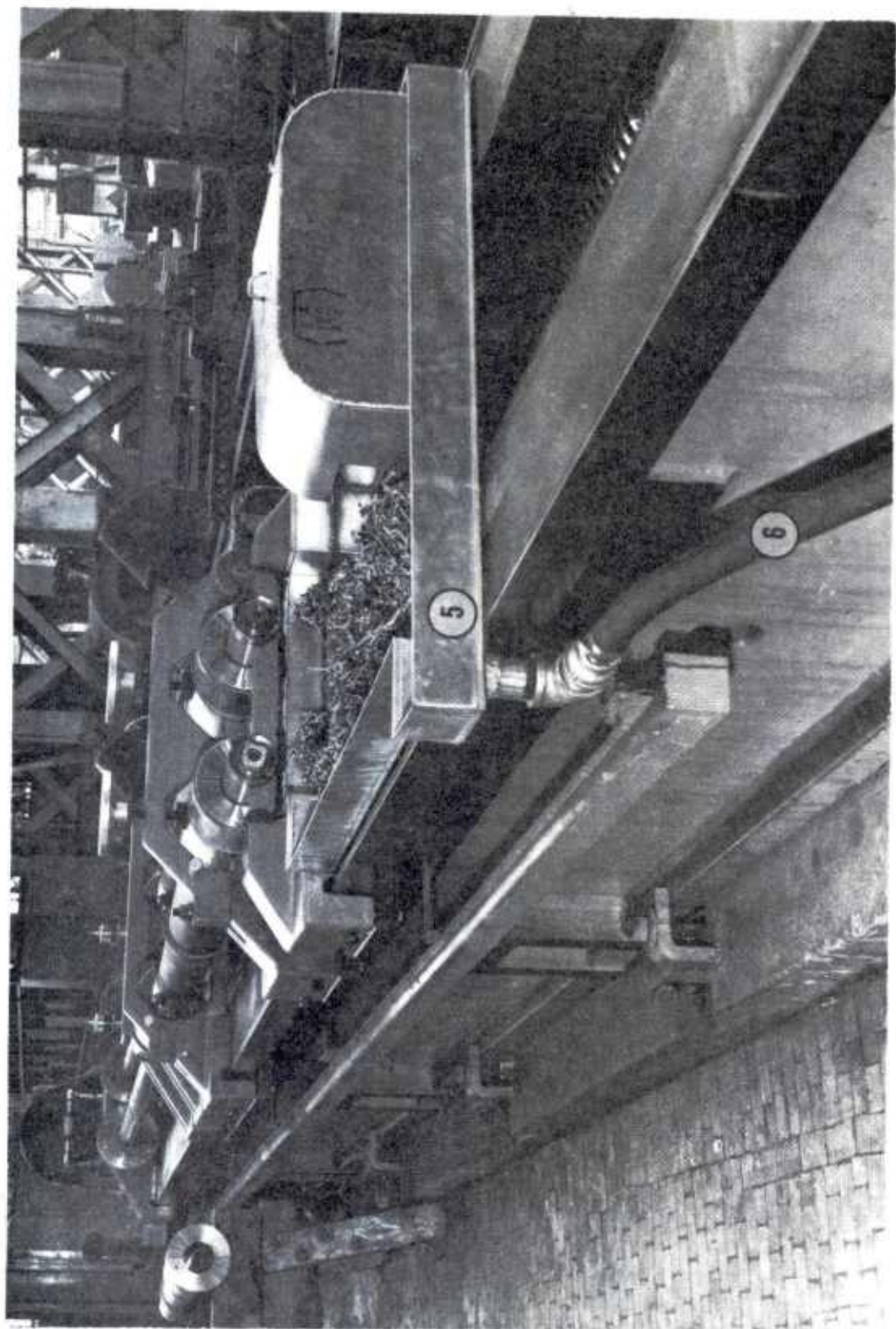


Figure 5. Overall view of duplex rifling bar setup showing coolant trough and coolant exhaust line (160-2-76).



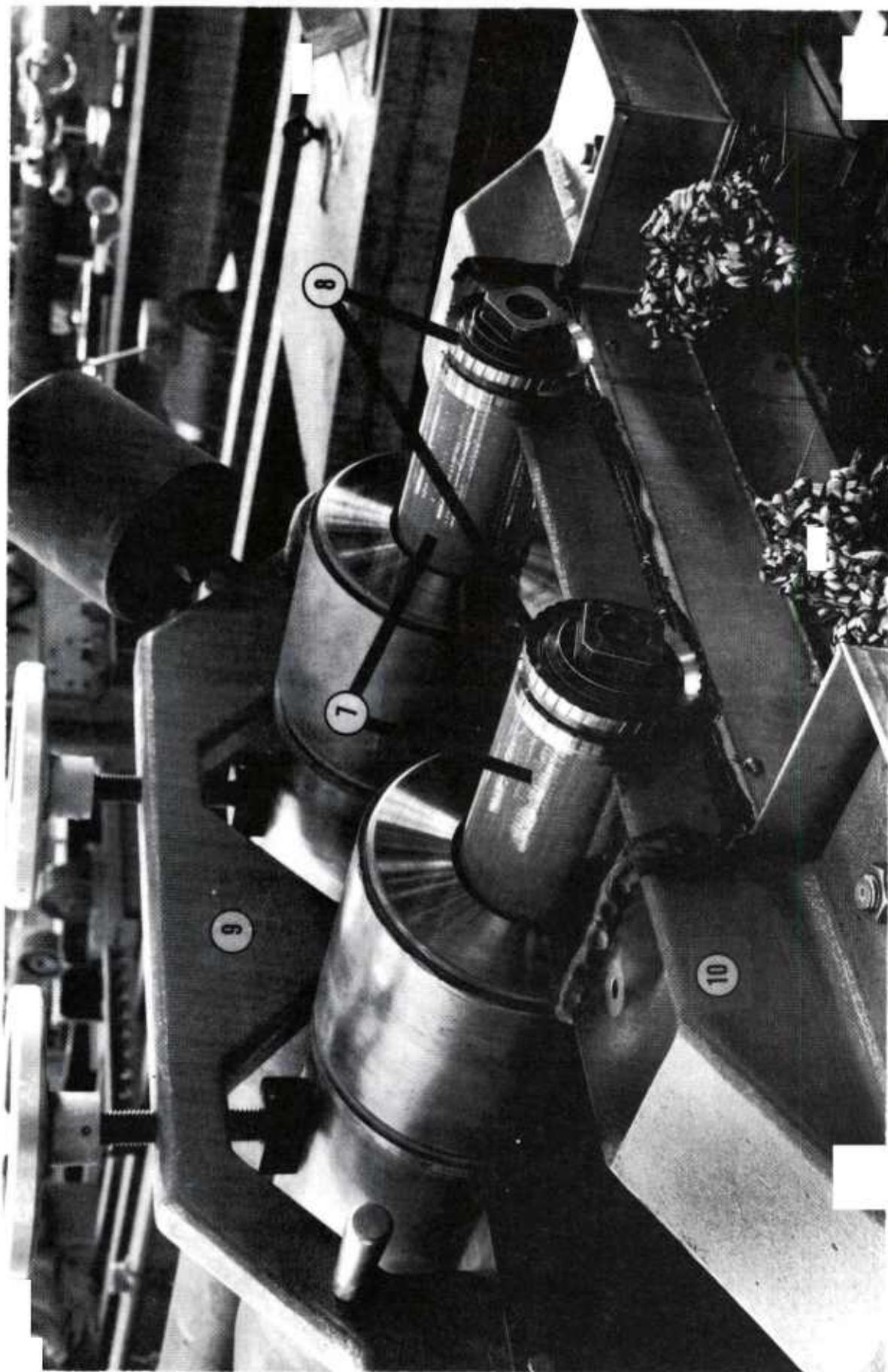


Figure 6. View of rifling heads with cutters mounted after completing a rifling cut. View of Tube Clamping Fixture, WTV-F24982, and Tube Positioning Fixture, WTV-F24981 (160-3-76).

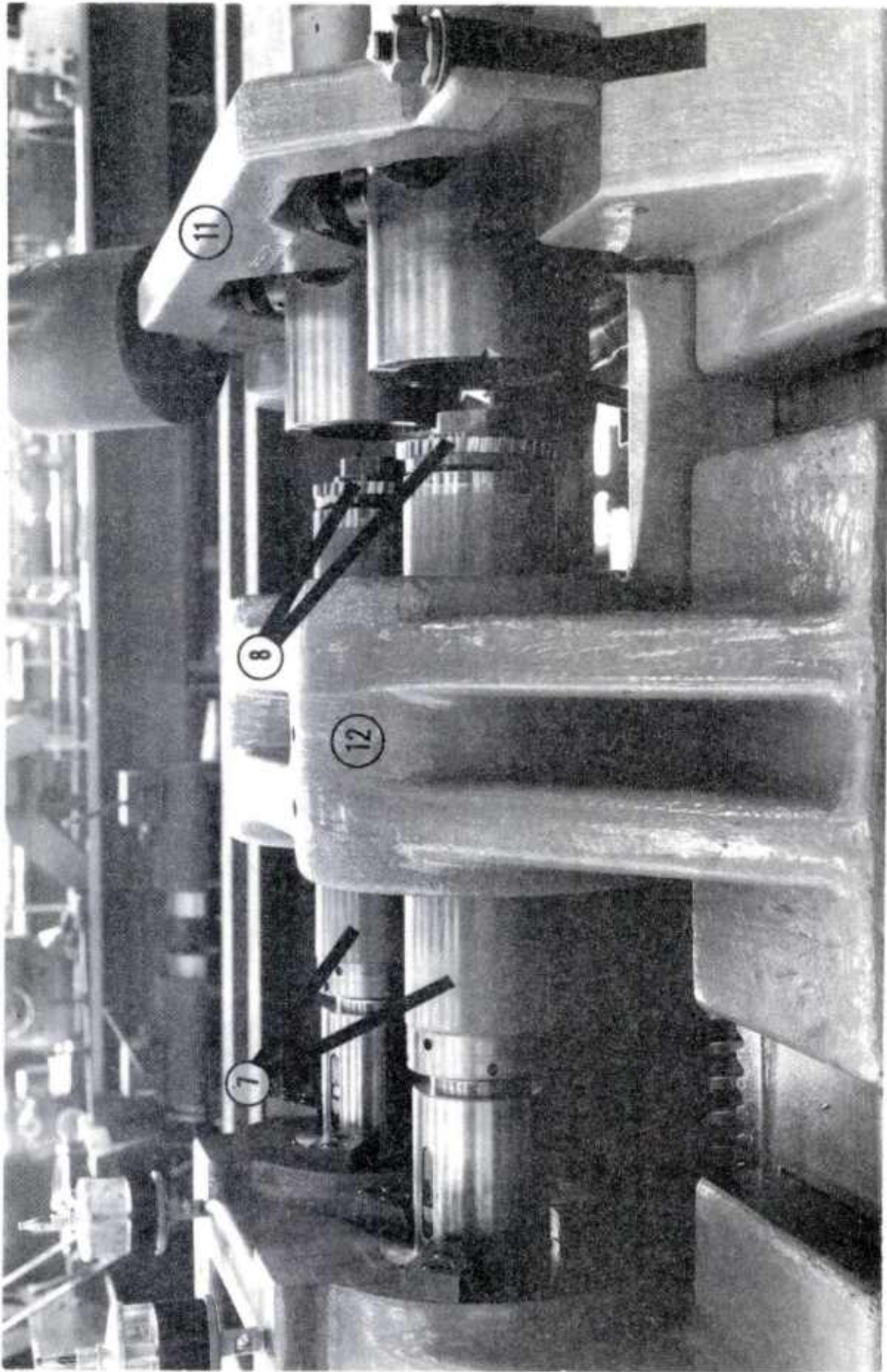


Figure 7. View of rifling broach heads mounted in rifling bars with rifling broaches mounted and aligned with muzzle ends of gun tubes which are supported in the Tube Centering Fixture, WTV-F24983 (160-4-76).



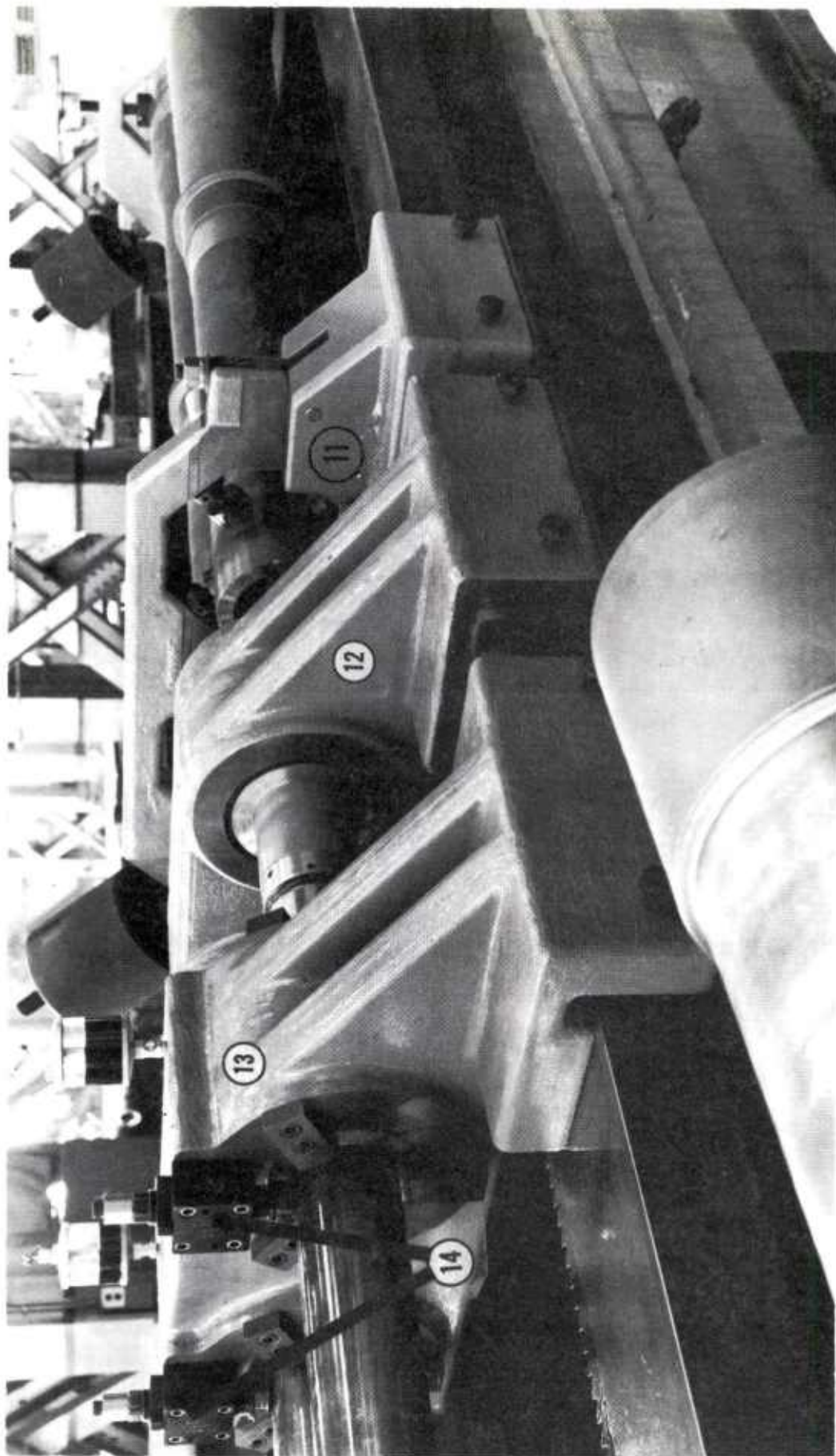


Figure 8. View of Rifling Bar Drive Yoke, WTV-F24985, Broach Support Fixture, WTV-F24984, and Tube Centering Fixture, WTV-F24983, showing key guide blocks for maintaining rifling helix (160-5-76).

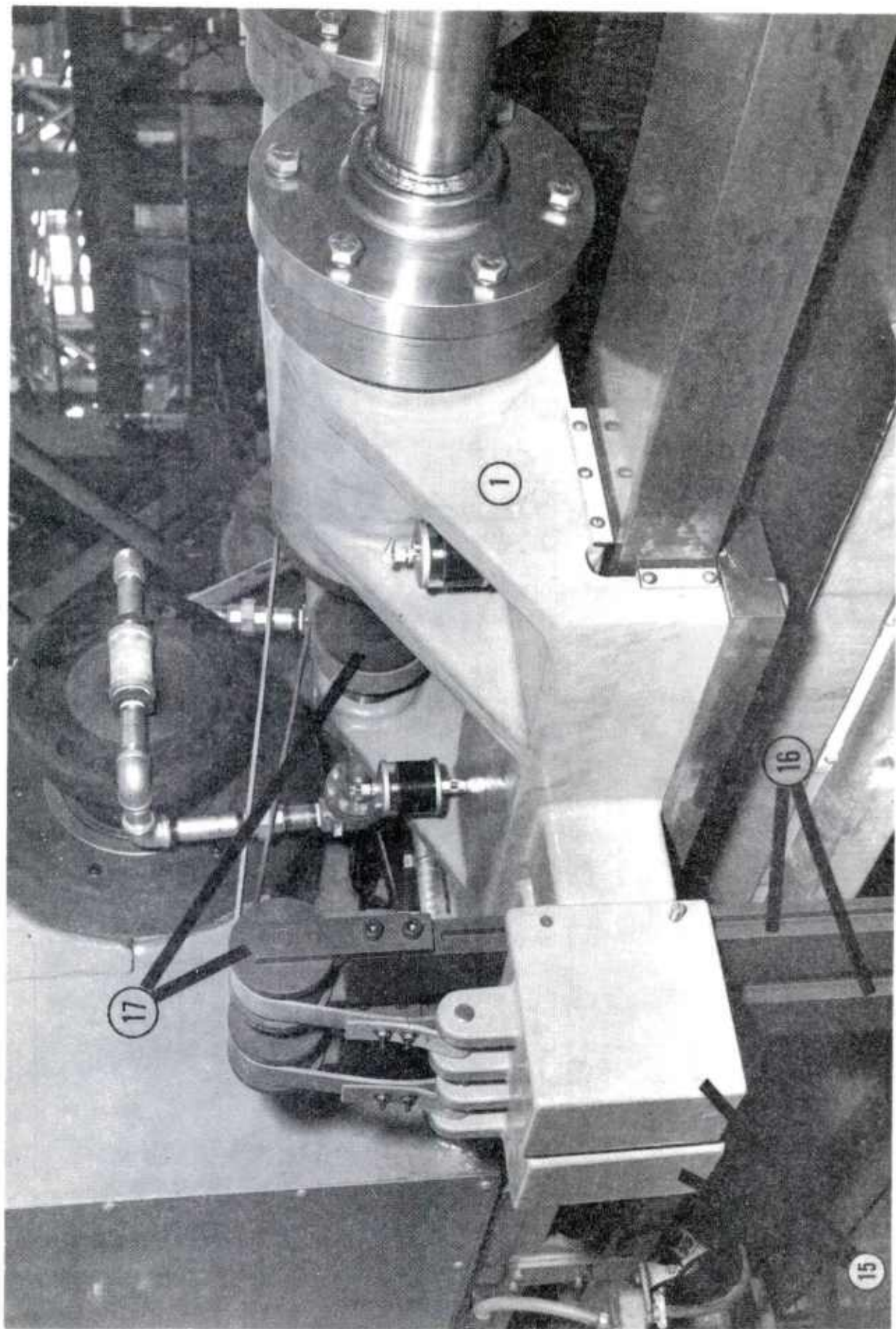


Figure 9. View of Crosshead Rifling Bar Drive, WTV-F24986, showing weights, weight guides, and pulley system (160-7-76).



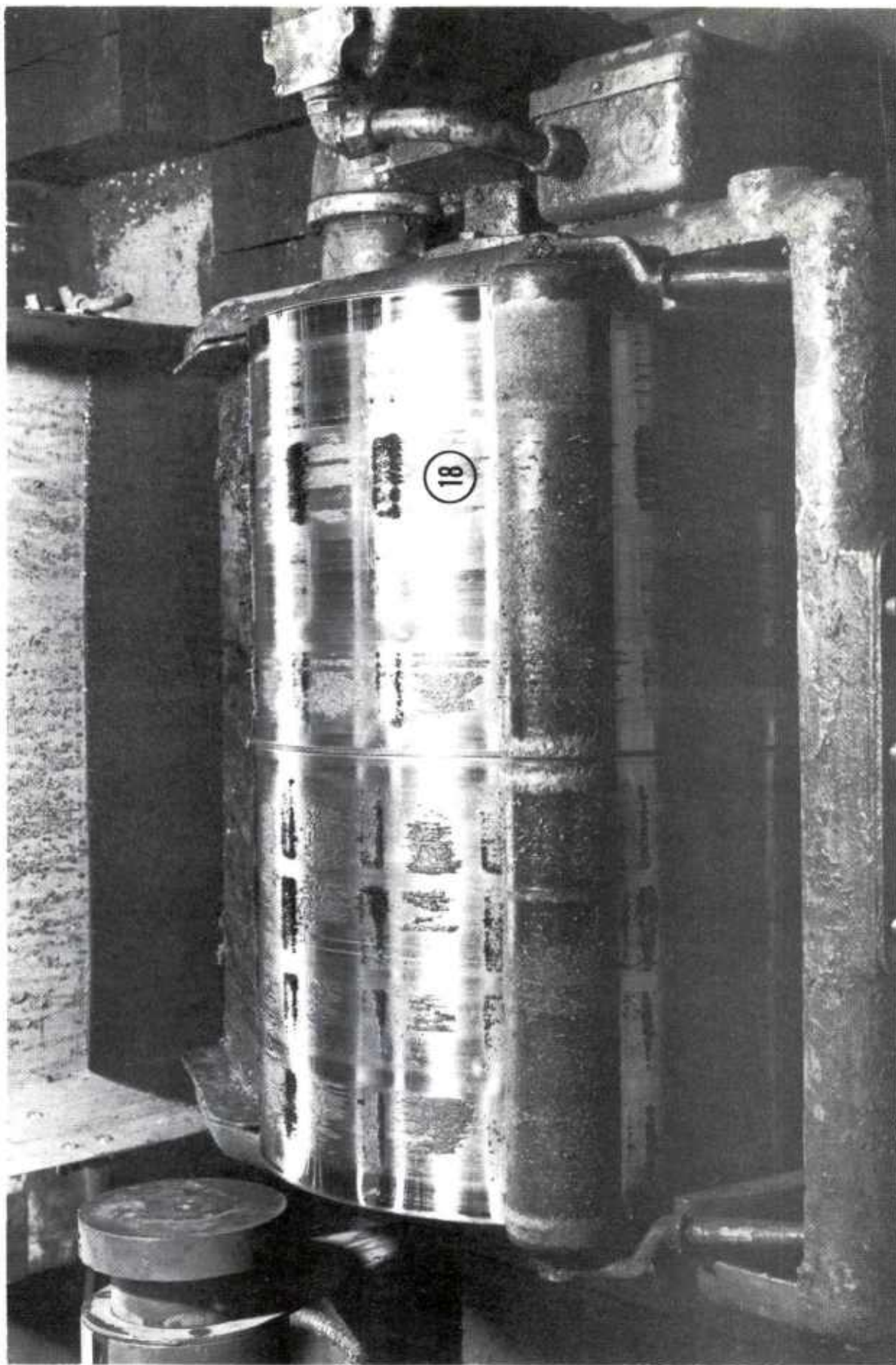


Figure 10. View of Metal Particle Separator used to keep steel particles from contaminating coolant oil (160-9-76).

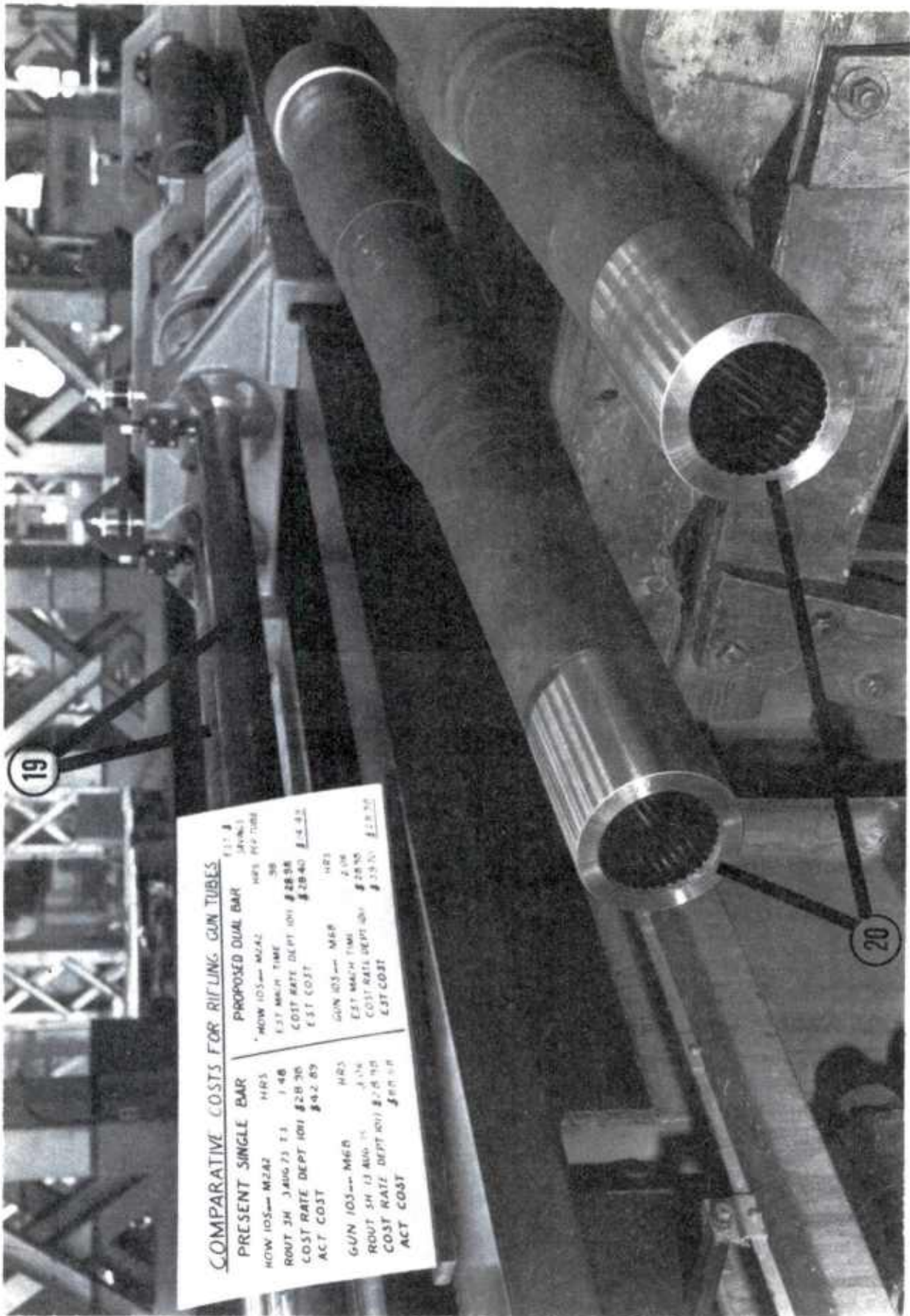


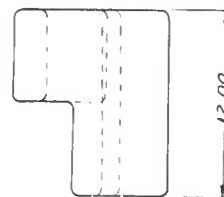
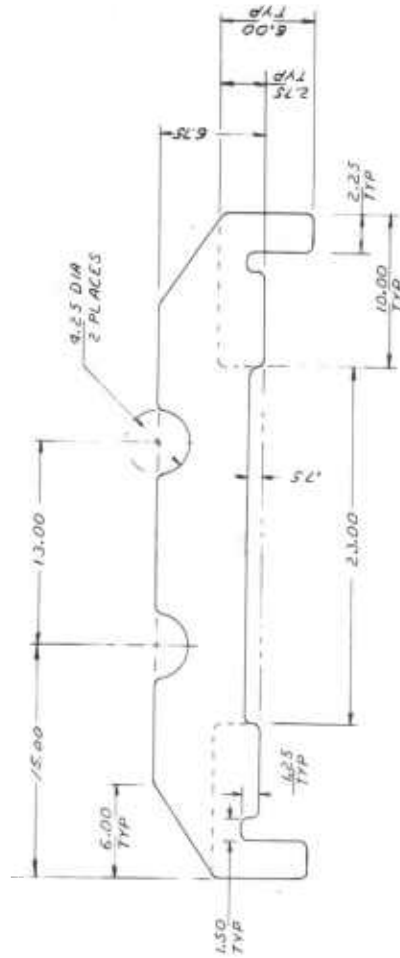
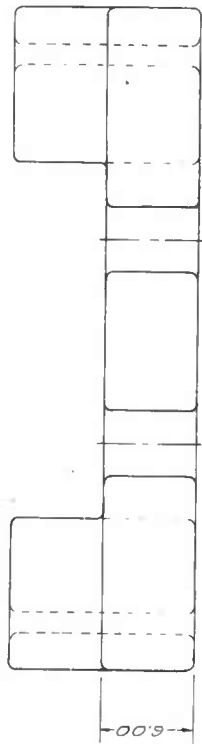
Figure 11. View of two 105mm M2A2 tubes, rifled by the Duplex Rifling System, and chart showing savings (160-6-76).



TABLE 1. COMPARATIVE COSTS FOR RIFLING TUBES

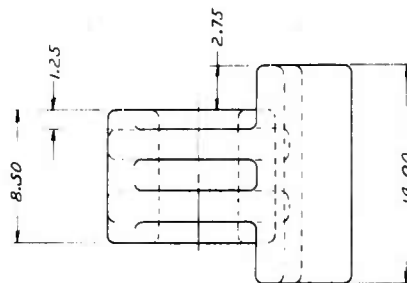
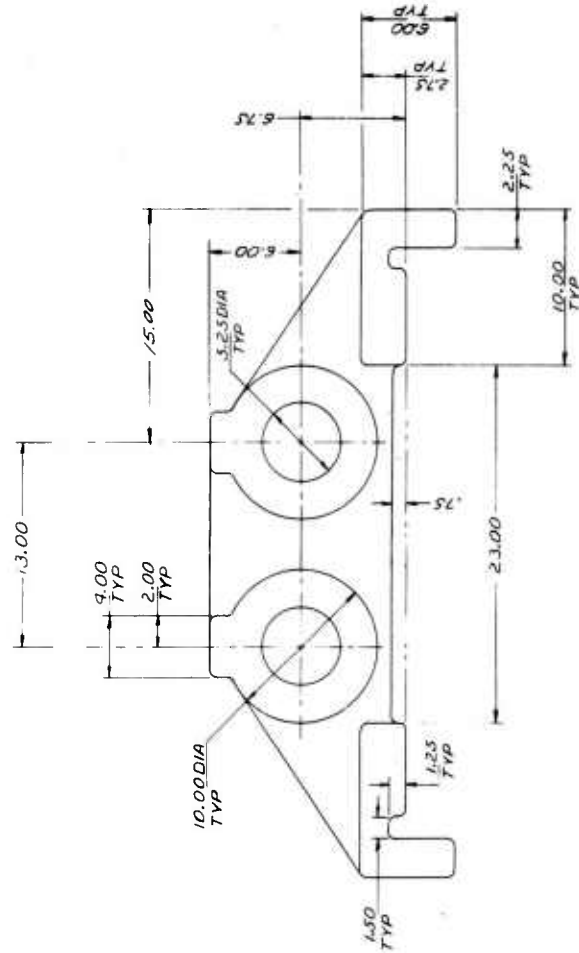
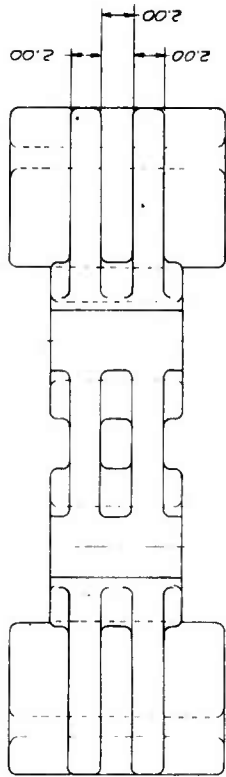
<u>Present Single Bar</u>		<u>Proposed Duplex Bars</u>		<u>Estimate &amp; Savings per Tube</u>
<u>How, 105mm M2A2</u>	<u>Hours</u>	<u>How, 105mm M2A2</u>	<u>Hours</u>	
Route Sheet (3 Aug 73) T.S.	1.48	Estimated Mach. Time	.98	
Cost Rate Dept. 1011 x	<u>\$28.98</u>	Cost Rate Dept. 1011 x	<u>\$28.98</u>	
Actual Cost:	<u>\$42.89</u>	Estimated Cost:	<u>\$28.40</u>	\$14.49
<u>Gun, 105mm M68</u>	<u>Hours</u>	<u>Gun, 105mm M68</u>	<u>Hours</u>	
Route Sheet (13 Aug 75)	3.06	Estimated Machine Time	2.06	
Cost Rate Dept. 1011 x	<u>\$28.98</u>	Cost Rate Dept. 1011 x	<u>\$28.98</u>	
Actual Cost:	<u>\$88.68</u>	Estimated Cost:	<u>\$59.70</u>	\$28.98

APPENDIX A  
Casting Drawings



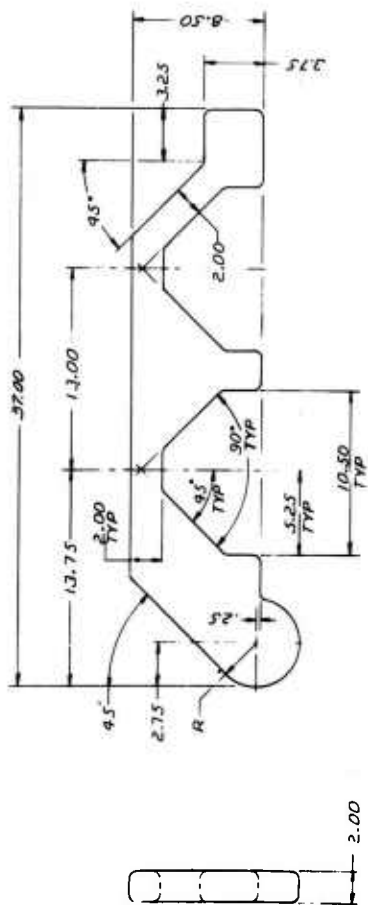
NOTE:  
ALL CAST FILLETS & EDGE RADII  
TO BE APPROX .50R.

Figure A-1. Tube positioning fixture (WTV-D25721).

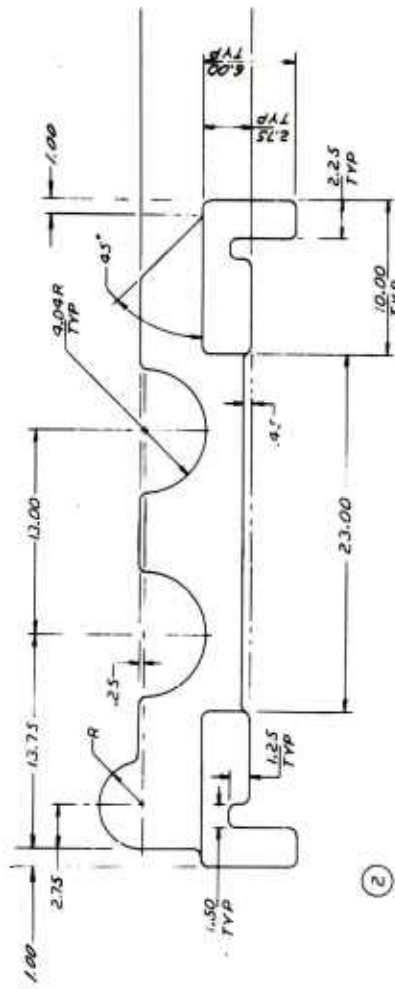
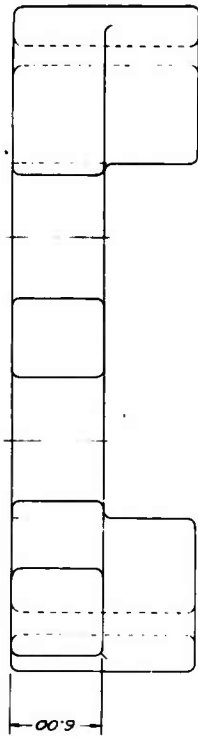


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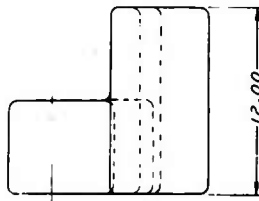
Figure A-2. Rifling bar drive yoke (WTV-D25722).



①



②



NOTE:  
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Figure A-3. Tube clamping fixture (WTV-D25723) .



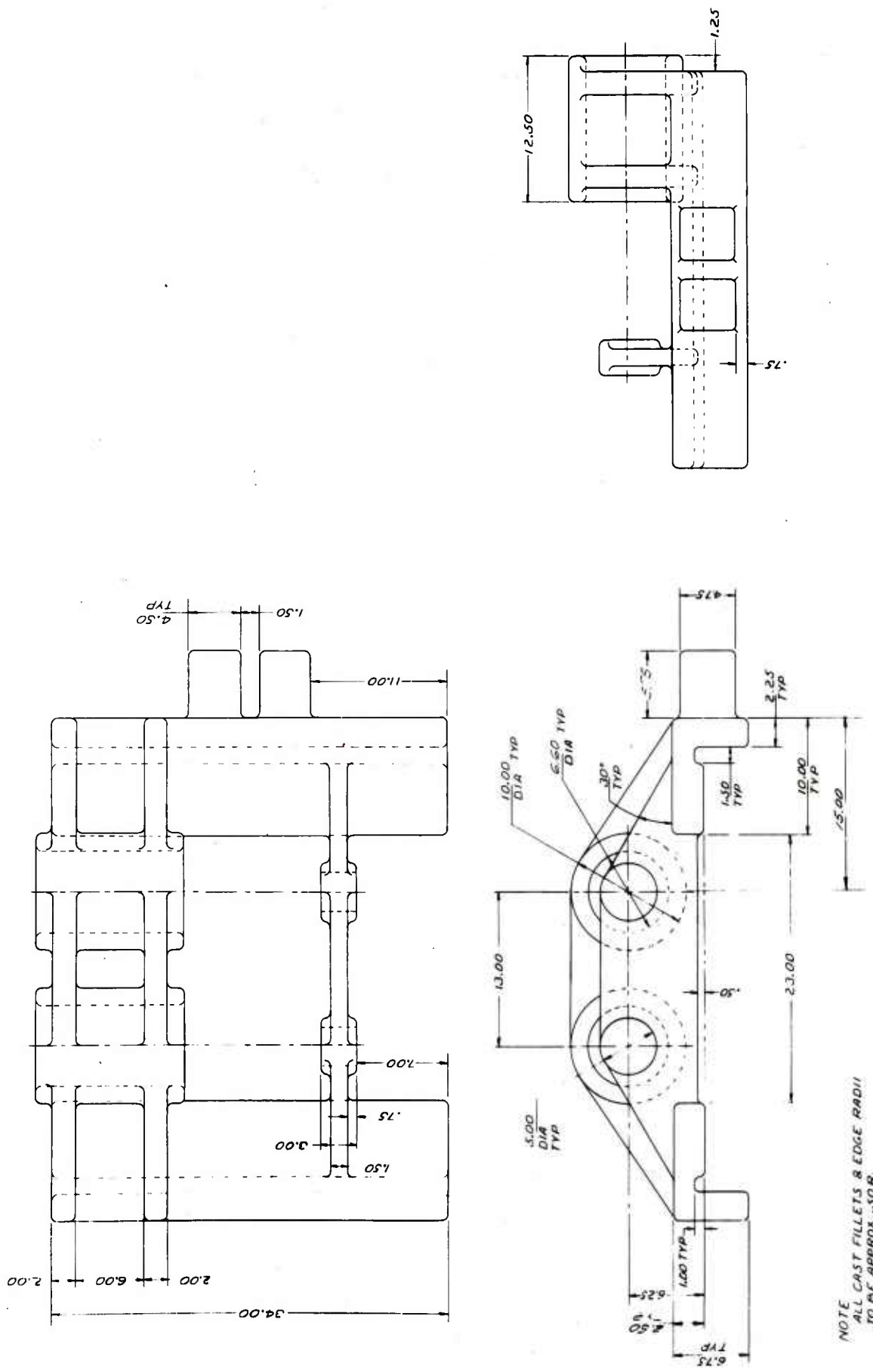
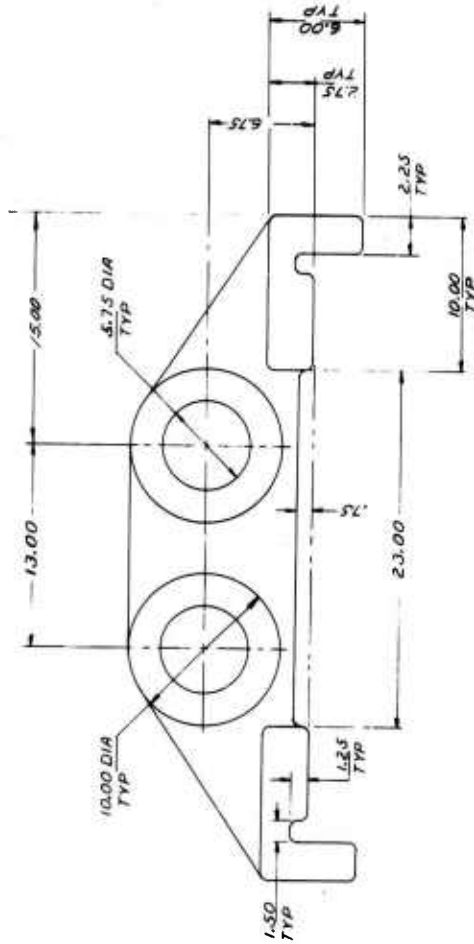
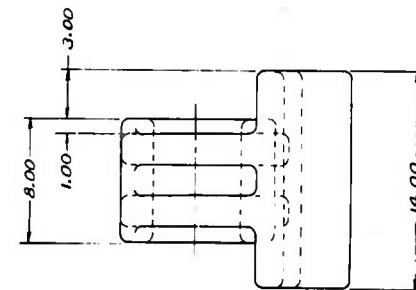
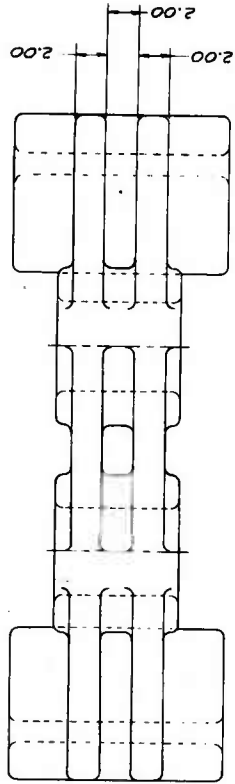


Figure A-5. Crosshead rifling bar drive (WTV-D25725).



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Figure A-6. Broach head support fixture (WTV-D25726).



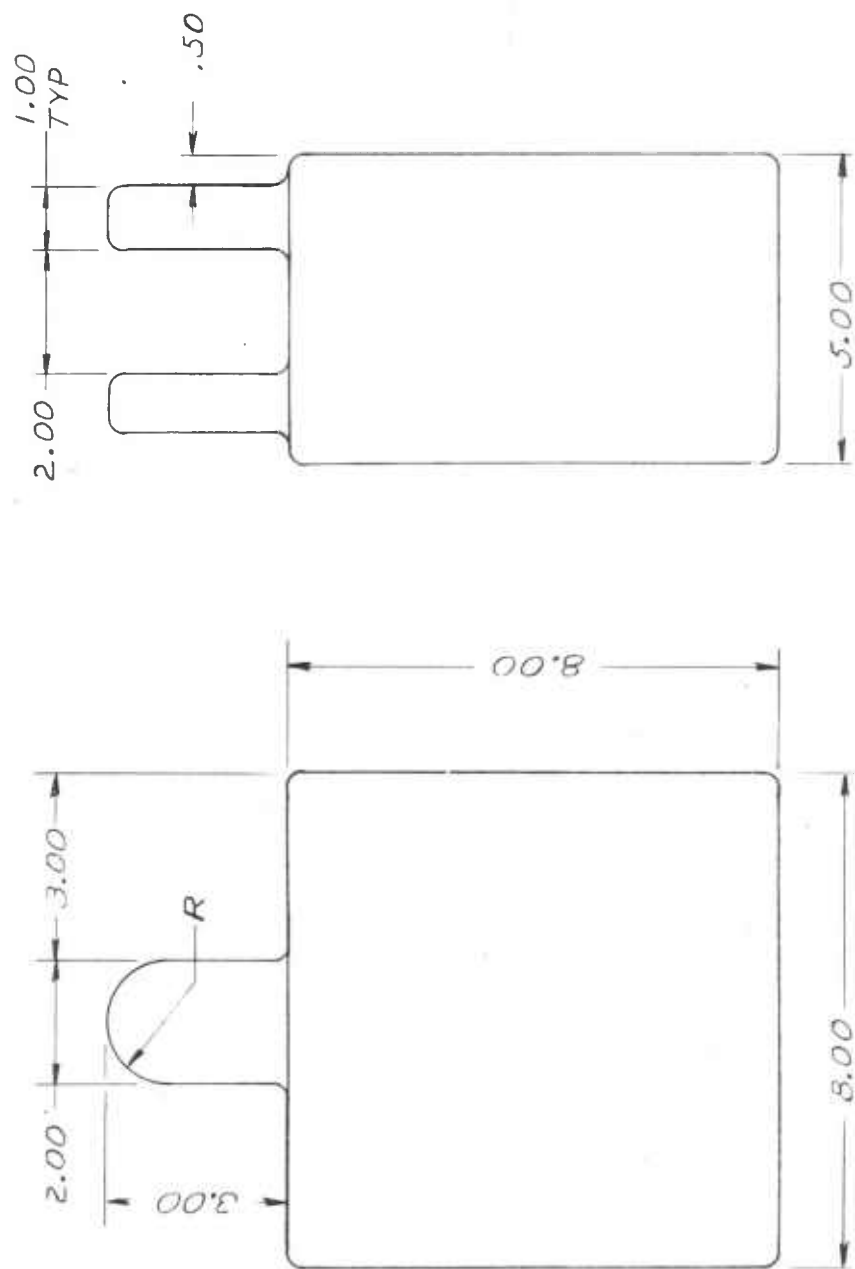


Figure A-7. Weight (WTV-B25720).

APPENDIX B

Finish Machined Drawings

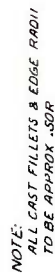


Figure B-1. Tube positioning fixture (WTV-F24981).

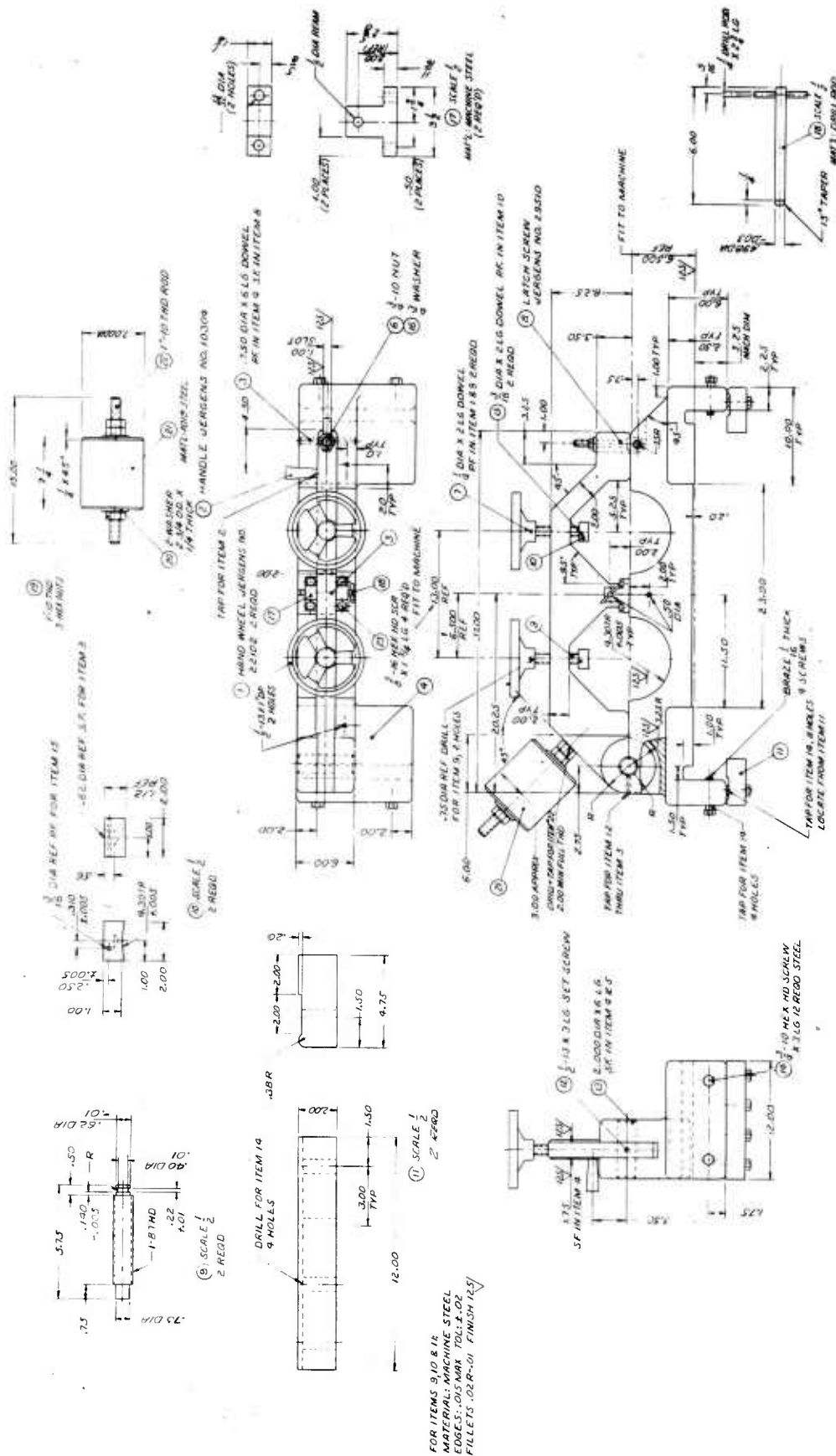
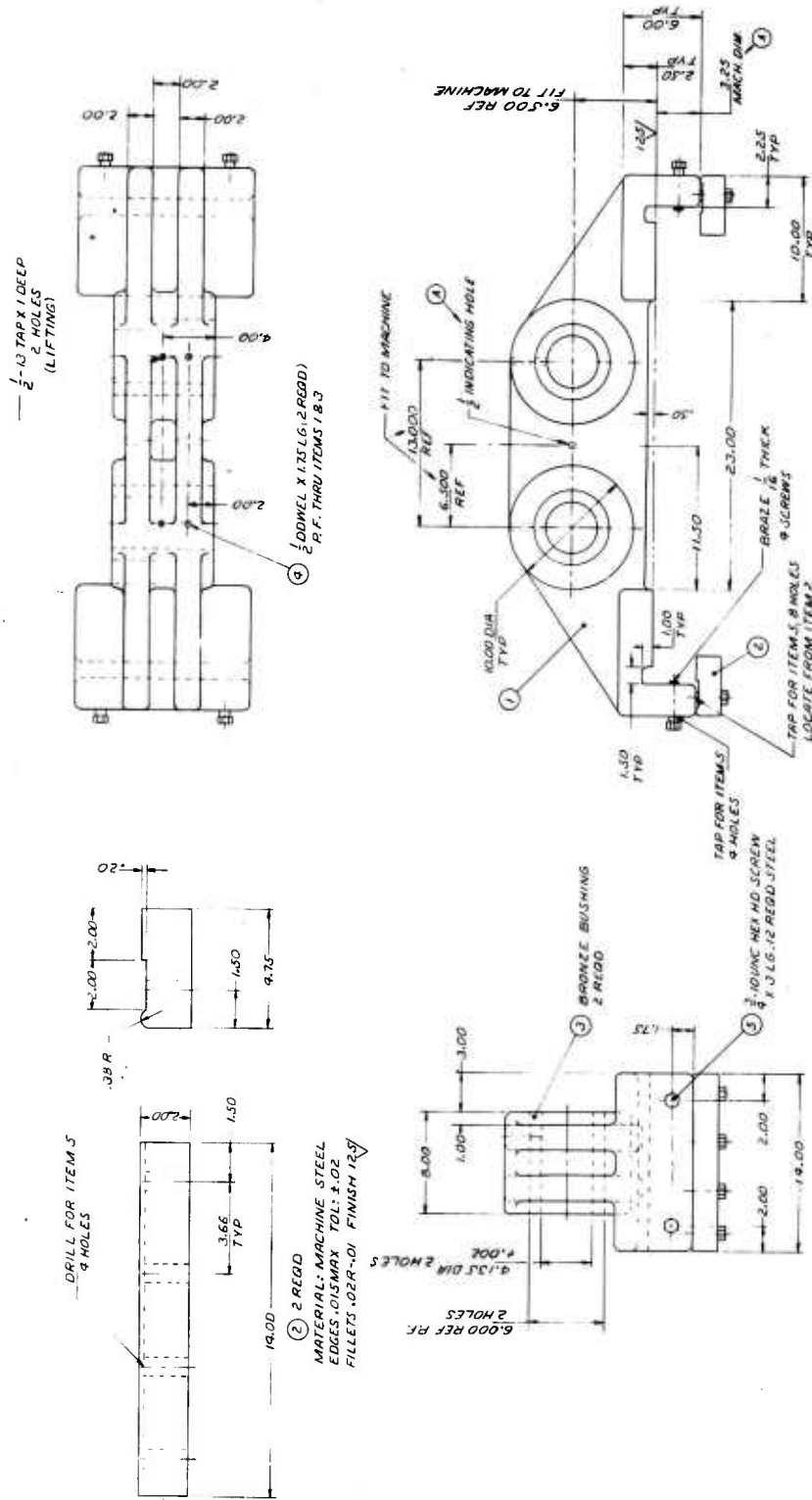


Figure B-2. Tube clamping fixture (WTV-F24982).





NOTE:  
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Figure B-4. Broach head support fixture (WTV-F24984).





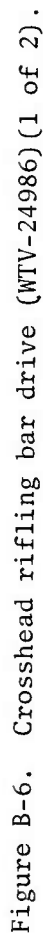






Figure B-7. Crosshead rifling bar drive (WTV-24986) (2 of 2).

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